

Bulletin of the Museum of Comparative Zoology

AT HARVARD COLLEGE

Vol. 111, No. 6

EXOTIC EARTHWORMS OF THE UNITED STATES

By G. E. GATES

CAMBRIDGE, MASS., U.S.A.

PRINTED FOR THE MUSEUM

MARCH, 1954



No. 6 — *Exotic Earthworms of the United States*

By G. E. GATES

This contribution is concerned primarily with material of non-lumbricid and peregrine species that has been received for identification during the last six years since the author returned from the orient. Most of the material had been collected on the mainland, some in Porto Rico from which only two species (both peregrine) had been recorded, a little from various extra-American sources. All of the forms that have been identified as to species are known to be exotic but there is some uncertainty as to two others (*Ocnerodrilus* and *Trigaster* spp.) from Porto Rico. Additional records for localities outside the United States have been included for several species.

The author's thanks are extended to the following who kindly supplied material: Dr. Fenner Chace, Dr. C. W. Coates, Mr. Walter Harman, Mr. Stephen Haweis, Dr. Libbie Hyman, Dr. J. A. MacNab, Mrs. Dorothy McKey-Fender, Dr. C. W. F. Muesebeck, Dr. G. E. Pickford, Prof. H. J. Lutz, Mr. Ottys Sanders, Mr. Rudy Stinauer, Mr. B. T. Thompson, and to Profs. M. A. Miller and T. I. Storer for information as to certain earthworms of California.

Family GLOSSOSCOLECIDAE

Genus PONTOSCOLEX Schmarda 1861

PONTOSCOLEX CORETHRURUS (Fr. Müller) 1857

Chatham, New Jersey, greenhouses on Southern Boulevard,
October 24, 1947, numerous juvenile and aclitellate specimens.

Mr. B. T. Thompson. (All of a second lot, supposedly of the
same species, were dead on arrival.)

Pana, Illinois, greenhouse, June 1948, 8 juveniles. Illinois
Biological Survey per Mrs. McKey-Fender.

Luquillo Forest, Porto Rico, recreation area, 1,800 feet, in
Caribbean National Forest, September 1, 1945, 6 clitellate
specimens. Dr. R. Kenk. (U. S. Nat. Mus. No. 184700.)

Mt. Joy, Dominica, British West Indies, "compost heap", June
19, 1949, 1 posterior fragment and 1 macerated clitellate
specimen. Mr. Stephen Haweis.

Hog Harbor, Espiritu Santo, New Hebrides, native gardens,
April 1927, 1 juvenile. Coconut plantation, at depth of a few
centimeters in volcanic soil, ca. 100 ft. elevation and one half
mile inland, 14.11.1927, 2 juvenile and 3 clitellate specimens.

14.3.1927, 5 juvenile and 4 clitellate specimens. Mr. J. R. Baker per Dr. G. E. Pickford.

P. CORETHRURUS?

Luquillo National Forest, Porto Rico, La Mina recreation area, 1,800 feet, Feb. 27, 1944, two specimens (one clitellate). Sept. 1, 1945, 38 specimens (4 clitellate). Sept. 16, 1945, 1 clitellate specimen. Sept. 22, 1945, 22 specimens (11 clitellate). Feb. 22, 1947, 29 specimens (8 clitellate). Dr. R. Kenk.

Barranquitas, Porto Rico, at 2,000 feet, 8/ix/1945, 8 specimens. Dr. R. Kenk.

Cidra, Porto Rico, "Treasure Island", 1,200 feet, Sept. 3, 1945, 3 specimens. Dr. R. Kenk.

Rio Piedras, Porto Rico, Sept. 16, 1945, 8 specimens. Mr. R. Cespo per Dr. R. Kenk. Farm on Trujillo Alto Road, 23/11/1947, 45 specimens (7 clitellate). Dr. R. Kenk.

St. Michel Plantation, Haiti, 1926, one posterior fragment. E. C. Leonard. (U. S. Nat. Mus. No. 91346.)

Jean Rabel, Haiti, Feb. 1929, 3 specimens. E. C. and G. M. Leonard. (U. S. Nat. Mus. No. 105088.)

Port de Paix, Haiti, 1.19-25.29, 1 fragment, E. C. and G. M. Leonard. (U. S. Nat. Mus. No. 105088.)

St. Thomas, D. W. I., hillside on north of island, July 18, 1915, 13 specimens. C. R. Shoemaker. (U. S. Nat. Mus. No. 58705.)

External characteristics. The apparent first segment is not as long as the next and its setae are only slightly behind its equator. The epithelium of the presetal portion does not have the smooth appearance of an external epidermis as does that of the postsetal portion.

Nephropores, on *c* lines, are recognizable from *iv* posteriorly on most specimens from the first four localities. A single nephropore is present on *iii* of one worm but on the other specimens nephropores could not be found on *iii* and *ii*.

Only one female pore is present (6 specimens), slightly in front of 14/15 and somewhat lateral to the *a* line, on the left side. The margin of the pore is very slightly tumescent and white (slight traction on the neighboring epidermis sometimes necessary to permit recognition of the actual aperture). A greyish translucent spot was noted at the expected site of a left pore but traction on the nearby epidermis of this as well as other specimens failed to reveal a definite aperture.

Tubercula pubertates are represented by a longitudinal band of grey translucence of the epidermis just lateral to the *b* line, on each side of the body.

Internal anatomy. Gizzard in vi (5). The ducts of the nephridia of iv, v and vi have been traced to the nephropores of those segments. The ducts from the two large clusters of nephridial tubules on the anterior face of 5/6 pass into the ventral face of the pharyngeal bulb.

Calciferous glands are directed laterally or dorsally so that the ducts pass from the mesial or ventral ends into the dorsal face of the gut. At the free end of the gland there may be recognizable a quite small, finely acinous lobe.

Remarks. Male pores again were not found. Seminal vesicles of each of the dissected clitellate specimens are juvenile and spermathecae are empty. External and internal characteristics of these specimens, except as indicated to the contrary above, are as previously noted (Gates, 1943, pp. 92-93).

Stephenson (1923, p. 490), Bahl (1942) and Gates (1943) disagree as to certain details of the excretory system in the anterior segments of this species. If the gizzard is in vi, as seems to be the case (Gates, 1943, p. 93, points out difficulties involved in segmental enumeration), then Bahl's segment numbering must be increased by one. The ducts of the large cluster of nephridial loops then would have opened on iii instead of ii. Stephenson and Gates, however, had found that the ducts of the large cluster pass into the pharynx. The condition of each of the present dissected clitellate specimens was such as to permit cutting of strands (muscular?) passing from the gut to the parietes so that the pharyngeal bulb could be lifted away from the body wall. When this had been done the ducts of the large nephridial cluster could be seen to pass into the tissues of the ventral portion of the pharynx. In the specimen with an apparent nephropore on iii, a translucent band of the same size and appearance as the nephridial duct passed into the body wall over the site of the nephropore, but the band had been broken and the point of emergence from the pharyngeal bulb was not found. In the other specimens, in which nephropores were lacking on ii-iii, no duct-like bands passed into the parietes at appropriate sites for nephropores. Presumably then there is some individual variation as to the manner of opening of the ducts of the nephridia belonging to iii. As no ducts were found between those of iv and those passing from the large cluster into the pharynx, it would appear that the large cluster usually is to be attributed to

segment iii, and that nephridia of ii are lacking. This is in agreement with Bahl, after the necessary change in his segmental numbering. It seems doubtful that the membrane which Bahl calls septum 1/2 is a normal intersegmental septum. Presence of septal funnels of nephridia of three different segments on the anterior face of 5/6 (Bahl's 4/5) also seems anomalous.

One of Mr. Thompson's specimens was left in the dirt in which it had been received, without watering. About a month later, on Nov. 22, the worm was found to be rather sluggish. On Jan. 5, the worm was rolled up into a tight ball which was sprung apart in the opening of the chamber in which it had been contained. The worm remained quiescent until it was dropped into alcohol and then only made a few slight movements. The gut was empty. Obviously the worm was in a state of diapause.

As worms of this particular species had been regarded as unwelcome guests in the greenhouses, an explanation was requested from Mr. Thompson who kindly supplied the following report. As a result of the presence of these worms, in the rose benches of the greenhouses, the soil becomes so hard that one can scarcely shove his fingers down into it. The worms are very sluggish and when they have started in the end of a bench, the infestation progresses at the rate of only fifty lineal feet a year in the same bench. Where they have not as yet infested, the soil is friable and loose. A fine soil sifts every day through cracks in the boards of the benches where the worms are present. This soil does not sift through in other places. These worms are brought into the greenhouses from a bank of soil in the rear where they have been living for at least ten years (data supplied in 1947). The worms will consume straw and green grass when put into the soil.

P. corethrurus is originally from some part of the American tropics and is now common throughout the world in the tropics, presumably as a result of transportation by man. There are no previous records from the continental United States. Successful establishment of a colony of this species at Chatham some time prior to 1937 presumably resulted from escape of the species from greenhouses into which it had previously been introduced with plants.

Many of the worms from the localities listed under the interrogation mark are much macerated. Each specimen has the quincunx arrangement of setae posteriorly. External characteristics and internal anatomy, insofar as determinable without special treatment, are as in *P. corethrurus*, to which species they probably do belong.

Many of these specimens had lost posterior portions of the body. Several have a long and metamerically segmented tail regenerate with terminal anus. Others have a shorter metamerically undifferentiated regenerate also with terminal anus. A fragment from the intestinal region of the body has an unsculptured (imperforate) cicatrix anteriorly and a short, metamerically undifferentiated regenerate with terminal anus posteriorly.

II

Family EUDRILIDAE

Genus *EUDRILUS* Kinberg 1866

EUDRILUS EUGENIAE Kinberg 1866

Lake Geneva, Florida, from culture beds of an earthworm farm, April 1952, 1 acitellate and 10 clitellate specimens. Mr. T. W. Baker per Dr. C. W. Coates.

Rio Piedras, Porto Rico, September 16, 1945, 15 specimens (8 clitellate). Mr. R. Crespo per Dr. R. Kenk. (U. S. Nat. Mus. No. 184700.)

St. Michel Plantation, Haiti, 1926, 1 macerated specimen. E. C. Leonard. (U. S. Nat. Mus. No. 9136.)

Nova Friburgo, Brazil, near the Rio Parahyba northwest of Rio de Janeiro, May 9-13, 1935, 7 macerated clitellate specimens. Dr. Doris M. Cochran. (U. S. Nat. Mus. No. 13273.)

External characteristics. Length, to 185 mm. Diameter, in clitellar region, to 6+ mm. Segments, 193+, 211+ (2 longest specimens). The anus in the Florida specimens (one exception) is slightly dorso-terminal. Ventrally there are marked off, in the anal region, two to five U-shaped metameres (incomplete dorsally) on some of which setae and nephropores are recognizable.

Remarks. In spite of the unusual size of the Florida worms (cf. Gates, 1942, p. 137), and the presence of a normally developed clitellum, metameric differentiation (and possibly production of segments?) had not been completed in the anal growth region of the two largest specimens.

Although the size might be thought to be indicative of favorable cultural conditions there is evidence that some environmental factors had been less than optimal; the presence of one or more metameric anomalies in every specimen in some part of the intestinal region of

the body behind xviii; presence on three of the eleven specimens of an extra caudal axis and on one of the three of a smaller tertiary caudal axis.

Bi- and trifold caudal regenerates have been obtained rarely in several species of earthworms (not including *E. eugeniae*), but the present monstrosities show no evidence that the extra axis or axes had resulted from regeneration.

Three anterior amputees were present in the West Indian lots. Amputation at some level behind 20/21, in one case, had been followed by healing without regeneration, the cicatrix unsculptured (imperforate). Loss of i-vi and part of the right side of vii had been followed by replacement of the missing portion of vii and development of a small conical bud without terminal invagination or other sculpturing. After loss of i-iii and parts of the left halves of iv-v, in the third case, the lost portions of iv-v had been replaced and a small bud had been developed with a blind (buccal?) invagination terminally. The nerve cord, somewhat widened, turns laterally in iv and passes up to the dorsal side where it is shortly bifurcated. A nerve cord thus bifurcated is found, at a certain stage of development, on the ventral side of a head regenerate. Perhaps the regenerate in this case would have developed into a dorsoventrally inverted head regenerate, a condition very rarely obtained.

The family Eudrilidae is purely African. *E. eugeniae*, the only species that is known outside of that continent, has been carried around the globe in the tropics, presumably by man, but had not hitherto been recorded from the continental United States. The species has been cultured for at least a year in New York City. Anglers, for whom these worms were raised in Florida, doubtless have been scattering them around the country and further records may perhaps be expected, presumably from the southern states.

E. eugeniae may have come originally from that part of Africa just north of the Gulf of Guinea.

III

Family MEGASCOLECIDAE

Genus PHERETIMA Kinter 1866

PHERETIMA AGRESTIS (Goto & Fatai) 1899

New York City, in the aquarium building at the Bronx Zoo,
September 1947, 2 clitellate specimens. July 2, 1949, 3 clitellate

specimens. July 1950, 4 clitellate specimens. Dr. C. W. Coates. (These worms were being raised to feed the platypuses.)

Albany, New York, in leaf mold and peat moss of a florist's nursery, July 1948, 8 clitellate specimens. (U. S. Nat. Mus. No. 108057.)

External characteristics. Segments, 101, 102 (2), 103, 104, 105, 106 (3), 108 (1). Pigmentation red, more marked on the preclitellar portion, or becoming light brownish behind the clitellum and gradually fading posteriorly. Prostomium epilobous, tongue open.

Setae begin on ii and are more closely spaced in the ventrum. Setal circles are without marked and regular breaks middorsally and mid-ventrally. The numbers in six specimens: 24, 32, 27, 27, 29, 28/ii; 35, 37, 40, 38, 34, 32/iii; 45, 45, 49, 38g, 43, 36/iv; 59, 64, 67, 54, 56, 53/viii; 61, 70, 76, 68, 62, 59/xii; 72, 67, 73, 63, 61, 55/xx; vi/23, 22, 24, 20, 21, 16g; vii/21, 26, 26, 16g, 23. 18g (g, one or more gaps with spaces for several setae).

Definite genital markings are again lacking but on vii (2), or viii (1), or vii-viii (4), there are paired areas of finely wrinkled epidermis on which setae may be lacking (in the latter case one or two setae may be present midventrally). These areas had a slightly brownish appearance, on at least one of the worms when alive, but after preservation coloration was no different from that of surrounding epidermis.

Internal anatomy. The intestinal caeca have 6-8 secondary caeca of which the dorsalmost sometimes has one or two small ventral pockets posteriorly. Dorsal sacculations of the intestine, in the caecal segment forward to xx, are not as marked as in *P. hilgendorfi*. The typhlosole is lamelliform in only about fifteen postcaecal segments, then gradually becoming more irregular, flattened and translucent. The ventral typhlosole is flat and ribbon-like but with a median groove. On the roof of the intestine along the mid-dorsal line, in specimens in which contents are not adherent to gut wall, there is recognizable a longitudinal series of pit-like depressions. Each pit is close to region of a septal insertion and has an opaque, whitish, tumescent margin. These pits, which may be well formed even after the typhlosole is no longer recognizable, were noted at the following sites: 48/49-68/69, 44/45-75/76, 50/51-68/69.

The last hearts are in xiii (17). Left heart of ix present (5), right heart (10), both hearts equally developed (2). Commissures of x apparently are lacking (17). The ventral trunk bifurcates anteriorly, the two branches uniting dorsally to form the dorsal trunk. Between

those bifurcations and septum 4/5 only two pairs of vessels (ventral portions of commissures of iv and iii?) pass out from the ventral trunk.

The testis sac of xi, in several worms, is u-shaped. Male funnels are plicate and medium-sized. Testes are mammiform to spheroidal. The testis sac, vesicles and hearts of xi may be bound to each other and to the septa by delicate connective tissue. Rudimentary pseudo-vesicles are present on the posterior face of 13/14 (17) just above the ovaries but no vesicles or sacs were found in xiv.

Spermathecae are large enough to reach well up onto gizzard. The duct is not as bulbous ectally as in some specimens of *P. hilgendorfi*.

Remarks. Worms with 69, 79, 90, 96, and 97 segments are unregenerate posterior amputees. Healing had been slightly asymmetrical, in one case, so that the anus was mostly on the left side. The elongated last segment of one amputee had lost all of its setae but sites of apertures of setal follicles were still recognizable in a complete circle.

The cuticle turns into the buccal cavity and in some much macerated specimens (from the Calif. Acad. Sci. labelled "Japan, 1877. Shiger-moto. Gustav Eisen. No. 4547") was recognizable as far back as x or xi. In the gizzard the cuticle was much thickened. The postgizzard collar of these Japanese worms is unusually large and deeply lobed. (There are numerous parasites in the coelomic cavities of iii-x).

P. agrestis has been reported from Baltimore and was recently found in the Arnold Arboretum at Boston (Gates, 1953b, pp. 5-8).

PHERETIMA CALIFORNICA Kinberg 1866

New Orleans and vicinity, La., logs, moist river bottom forest, Dec. 31-Jan. 1, 1931-32, 3 clitellate specimens. J. M. Valentine, per Dr. G. E. Pickford.

New Orleans, La., Jan. '42, 2 clitellate specimens. E. Liebman, per Dr. G. E. Pickford.

Poughkeepsie, N. Y., leaf pile below greenhouses of Vassar College, Aug.-Nov. 1 clitellate specimen. V. L. Fogerson, per Dr. G. E. Pickford.

Poughkeepsie, N. Y., pile of dirt in unheated greenhouse of Vassar College, 1 clitellate specimen. V. L. Fogerson, per Dr. G. E. Pickford.

Waterral Baven, eastern Transvaal, South Africa, 16.iv.'27, 1 juvenile and 1 clitellate specimens. Dr. G. E. Pickford.

As the name suggests this species must have become established in the United States more than a century ago.

PHERETIMA DIFFRINGENS (Baird) 1869

New Orleans and vicinity, Louisiana, logs, moist river bottom forest, Dec. 31-Jan. 1, 1931-32, 3 clitellate specimens. J. M. Valentine, per Dr. G. E. Pickford.

New Haven, Conn., Yale Botanic Garden at Prospect Street, Aug. 19, 1943, 2 a clitellate and 1 clitellate specimens. Dr. G. E. Pickford.

Uvalde, Texas, rotten log, June 1938, 3 a clitellate and 5 clitellate specimens. John Robinson, per Ottys Sanders.

Boone's Cave, N. C., July, 1946, 1 clitellate specimen. Dr. C. D. Howell.

Lincoln, Nebraska, soil near University greenhouses, August, 1927, 1 a clitellate and 5 clitellate specimens. Dr. J. A. Macnab.

Anniston, Alabama, humus in marshy places, June, 1949, 5 clitellate specimens. Wilfred W. Staples, per Dr. Libbie Hyman. (These worms were reported to be known locally as "black wrigglers".)

Fayetteville, Arkansas, wet soil with large admixture of bark from walnut and other lumber in grounds of Brower Veneer Mill, August 17, 1949, 3 clitellate specimens. Dr. W. J. Baerg, per Dr. C. W. F. Muesebeck. (Dr. Baerg reported an attempt to rear this species for sale as fish bait.)

Gainesville, Florida, grounds about agricultural college, Sept. 30, 1914, 1 a clitellate specimen. F. E. Watson, per Am. Mus. Nat. Hist. (Acc. No. 5007, Field No. 3612).

Ruston, Louisiana, yard of apartment house, March 1951, 14 clitellate specimens. Mr. Walter Harman.

Dayton, Oregon, under flats in greenhouses, March 17, 1951, 1 a clitellate and 2 clitellate specimens. Mr. Ray Albright per Mrs. Dorothy McKey-Fender.

Dayton, Oregon, under flats in Albright Greenhouses, March 18, 1951, 1 clitellate specimen. Mrs. Dorothy McKey-Fender.

McLean, Virginia, in "deep woods", August 1953, 1 clitellate specimen. Mr. A. D. Cushman per Dr. C. W. F. Muesebeck.

Chapulhuacan, Mexico, 7/12/37, 1 clitellate specimen. Ottys Sanders. (Posterior fragments of two other specimens probably are of the same species.)

Nova Friburgo, Brazil, near the Rio Parahyba northwest of Rio de Janeiro, May 9-13, 1935, 1 macerated clitellate specimen.

Dr. Doris M. Cochran. (U. S. Nat. Mus. No. 13273.)

Kirstenbosch, South Africa, on grass near pond, 2.iii.'27, 1 clitellate specimen. Dr. G. E. Pickford.

Salisbury, South Africa, in bank of Makabusi River, 3/7/27, 4 clitellate specimens. Dr. G. E. Pickford.

Remarks. The gut of the Nebraska specimens (straight and in a splendid condition rarely available) is strongly sacculated in xx-xxvi but there is no indication of demarcation into dorsal and ventral pockets as in *P. hilgendorfi*. The typhlosole (scarcely represented anterior to the caecal segment, xxvii) is low, straight, opaque, rather thin and lamelliform to the region of l-liv. From thence posteriorly it is slightly thicker, lower, rather translucent and regularly interrupted. Just in front of each level of septal insertion the ridge bifurcates, each branch decreasing rapidly in height as it passes diagonally and posteriorly to the midventral line. A pit comparable to those found in *P. hilgendorfi* is present on the roof of the gut middorsally just behind each bifurcation. The typhlosole ends abruptly in lxxxii (worms of 109, 114 and 116 segments), lxxxiii (worms of 109 and 115 segments) but in lvi of an autotomized worm (of 77 segments), in lxi and lxxiii in worms with tail regenerates (at 95/96 and 94/95 respectively).

Both testis sacs are above the nerve cord. The ventral blood vessel is imbedded in testicular coagulum within the posterior sac at least. Prostates are lacking in the Nebraska specimens but prostatic ducts are well developed.

The anterior pair of spermathecae is lacking in two of the Ruston specimens and the spermathecae of the other segments lack ampulla, diverticulum or both. The spermathecae of one of those worms are covered with parasitic cysts.

Maximum number of segments found in tail regenerates is five.

This species probably has been established in the United States at least as long as *P. californica*. Although it had been collected in California prior to 1867 the earliest record yet found to the East (Illinois) that is likely to have been of this species is 1888.

PHERETIMA HAWAYANA (Rosa) 1891

New Orleans and vicinity, La., logs, moist river bottom forest, Dec. 31-Jan. 1, 1931-32, 1 clitellate specimen. J. M. Valentine, per Dr. G. E. Pickford.

New Orleans, La., Jan. '42, 2 clitellate specimens. E. Liebman, per Dr. G. E. Pickford.

Pana, Illinois, greenhouse, June, 1948, 1 clitellate specimen. L. L. English, per Ill. Biol. Survey.

Nashville, Tenn., Jay's greenhouses, Jan. 1947, 1 a clitellate and 4 clitellate specimens. Lester Eck, per Ill. Biol. Survey.

Auburn, Alabama, Farm Ponds Laboratory, May, 1947, 1 a clitellate and 5 clitellate specimens. E. E. Prather, per Ill. Biol. Survey.

Lutz, Florida, spring of 1950, 8 clitellate specimens. Dr. H. S. Hain, per Dr. C. W. Coates. (These worms were being raised for sale as bait, in a bed of muck and manure on white sand, in the shade of cypress trees.)

Lutz, Florida, March 1951, 8 clitellate specimens. Dr. C. W. Coates.

Dayton, Oregon, under flats in Albright Greenhouses, March 18, 1951, 1 clitellate specimen. D. McKey-Fender.

Los Angeles City College, California, June 15, 1951, 2 a clitellate and 19 clitellate specimens. Prof. A. W. Bell, per Mrs. Dorothy McKey-Fender.

Jackson, Michigan, 4 clitellate specimens. Rudy Stinauer. (These worms were secured from a bait dealer who was said to have obtained them from Florida.)

Nova Friburgo, Brazil, near the Rio Parahyba northwest of Rio de Janeiro, May 9-13, 1935, 2 macerated clitellate specimens. Dr. Doris M. Cochran. (U. S. Nat. Mus. No. 13273.)

Madeira, Funchal, 9.viii.1928, "wet vegetable mould," 1 clitellate specimen. Dr. G. E. Pickford.

A spiral abnormality involves viii-x of one Florida specimen.

A tail regenerate of about 14 segments, at 49/50 also has spiral abnormalities in the proximal portion. A tail regenerate at 63/64 has 9 (+?) segments, the proximal metamere with setae ventrally, complete circles on the next five segments followed by three which are clearly demarcated but without setae. The anus is terminal.

P. hawayana may have been one of the species that had become established in Illinois prior to 1888.

PHERETIMA HILGENDORFI (Michaelson) 1892

Kingston, Ulster County, New York, September 13, 1948, 5 clitellate specimens. T. P. Weyhe, per New York State Museum and the U. S. Nat. Mus.

Bronxville, Westchester County, New York, September 1950, 7 clitellate specimens. Dr. Wm. J. Robbins per Dr. C. W. Coates.

Michigan, beside Ox Creek, just north of Benton Harbor, Berrien County, October 21, 1950, 2 clitellate specimens. Mr. Rudy Stinauer. (7 a clitellate and 1 clitellate, much macerated specimens, received earlier in the year presumably were from the same locality.)

Middleburg, Virginia, October 24, 1950, 1 clitellate specimen. December 12, 1950, 4 clitellate specimens. (U. S. Nat. Mus. Nos. 188565 and 189104) Miss June Badger. (These worms were said to be "extremely lively". Used for food for certain animals in the National Zoological Park.)

External characteristics. Length, of complete specimens, 109-130 mm. Diameter, 6-8 mm. Segments, (87, 1 specimen), 98 (2), 105, 107, 108 (2), 109 (2), 110 (2), 111, 113 (3), 114, 116. Pigmentation, red, restricted to dorsum (unrecognizable in Kingston specimens, alcoholic preservation). Prostomium epilobous, tongue open.

The setae begin on ii, the circles with no marked, regular break middorsally or midventrally, gaps when present irregular and mostly slight. Setal circles of xvii-xx, as well as of more posterior segments, are uninterrupted. Setal numbers are shown below.

Variation in number of setae in *Pheretima hilgendorfi*

Segment	ii	iii	viii	xii	xx	vii/sp
	17	18	50	51	56	23
	20	28	49	54	58	12*
	22	27	54	56	55	22
	23	30	51	60	59	26
	23	34	56	58	62	23
	26	31	55	54	59	24
	24	32	55	61	61	25
	27	30	59	56	61	22
	26	38	60	66	57	26
	22	34	47	56	50	22

sp setae between spermathecal pore lines.

* gaps present in circle.

On the macerated specimens number of setae between spermathecal pore lines varies between 24 and 28.

The first dorsal pore is apparently on 11/12 (8, including seven macerated specimens), 12/13 (13, but with an apparently non-functional marking on or near 11/12 in 6), 13/14 (2, but with an apparently non-functional marking on 12/13 on one). The clitellum (annular) reaches to 13/14 and 16/17 but with pores of those furrows not occluded, intersegmental furrows and setae unrecognizable, dorsal pores of 14/15 and 15/16, except on one specimen, occluded.

Quadrithecal, spermathecal pores very small (but larger than female pore) transverse slits with slightly whitened margins, nearly $\frac{1}{2}$ C apart, on 6/7-7/8. The female pore is median (10).

Genital markings small, clearly demarcated, circular tubercles, each with a minute central aperture, in unpaired median presetal patches on viii (32), viii-ix (6), viii-x (1, with a single marking on xii), viii-xi (1). The patches are closer to the intersegmental furrows than to the setal circles and the tubercles are in 1-5 rather irregular transverse rows of 3-5 each, a patch containing 3-24 tubercles.

Internal anatomy. Septa 8/9-9/10 lacking, none markedly thickened though 11/12-12/13 are more opaque than the others and obviously with some slight muscularity (7). Postgizzard glandular collar on the oesophagus markedly iridescent and deeply lobed. Intestinal origin in xv (10). Intestinal caeca manicate, with 7-9 secondary caeca; the dorsalmost the longest and thickest, reaching into xxii, xxiii or xxiv, the ventralmost shortest and only about 2-3 mm long. The gut from the caecal segment through xx is markedly sacculated, two dorsal rows of sacculations extending from the middorsal to midlateral levels, a row of still more marked sacculations extending from midlateral to midventral levels. Typhlosole low but lamelliform, decreasing in height and flattening out irregularly passing posteriorly, ending in lxxix (specimen of 113 segments). Pits are recognizable (December Middleburg specimen) at levels of 47/48-69/70 (typhlosole ends in lxxi). Ventral typhlosole flat and ribbon like, from first, second or third postcaecal segment through 16-17 segments.

Last hearts in xiii (11). Left heart of ix present (5), right present (5), both hearts of ix present but that of left side much smaller (1). Commissures of x lacking (10) or represented by a pair of small blood-filled vessels passing ventrally from the supra-oesophageal (1). Sub-neural trunk continued into iii, bifurcating anterior to the subpharyngeal ganglion. The dorsal trunk passes under the brain.

Testis sacs unpaired and ventral, above the nerve cord, the ventral trunk apparently included and just below the roofs. Testes rather

mammiform, the protuberant central nipple-like portion brownish. Male funnels plicate, medium-sized. Seminal vesicles rather small, low down in coelomic cavities, those of xi bound by connective tissue to the testis sac, those of xii sometimes marked off into distinct ampulla and lamina. Pseudovesicles in xiii (8) may be as large as the vesicles of xii. Ovisacs or vesicles of any sort were not found in xiv (7). Vasa deferentia apparently end usually in a slightly pear-shaped swelling, in xvii, xviii, even xix or xx though a filament may pass from the enlargement into the parietes. The ducts of the Kingston specimen were continued into xxiii or xxiv where they ended without any terminal swelling.

Spermathecae fairly large, reaching well up onto the gizzard. The duct, which may have an obvious muscular sheen, is more or less widened towards the parietes so as to have a rather flask-shaped appearance but is much narrowed just at or within the parietes. The diverticulum is longer than the main axis and comprises a stalk portion with muscular sheen and a slightly thicker seminal chamber of variable shape and thin translucent wall. The diverticulum passes into median face of the duct close to the parietes.

Genital marking glands have long coelomic stalks.

Remarks. A 96 mm. worm of only 87 segments, the last of which has a complete circle of setae, appears to be a posterior amputee. The penultimate segment has no setae (7 specimens), or about eight on the right side only (specimen of 108 segments). A complete circle of setae is present on the penultimate segment of three Kingston worms (of 98, 98 and 113 segments). The last segment of specimens having 70 and 72 segments has a complete circle of setae, the small anal regenerate not marked off from substrate by an intersegmental furrow.

The oesophagus, including the pharyngeal bulb, contained no soil but the gizzard lumen in each of the dissected specimens was filled with earth. The lumen of the oesophagus in x-xiii of several specimens was filled with a reddish translucent material of jelly-like consistency. A piece of a midrib of a leaf, about nine mm. long, with small bits of the lamina still attached, was found in one intestine. The cuticle turns into the gut at the anus and in favorable conditions can be recognized for some distance forward.

Each spermathecal pore of some of the worms is on a hemispheroidal tubercle with smooth, greyish translucent surface. The tubercle usually is slightly sunk into the body wall so that its periphery is covered by a slight preputial-like protuberance. The region around each

spermathecal pore of the December Middleburg worms is whitened and tumescent, with greyish translucent spots similar in appearance to those of the genital marking patches. No stalked glands corresponding to these areas were found internally though they could have been concealed from view in the muscular layers. The narrowed parietal portion of the duct, after dissecting the spermatheca out of the body wall, appears as a shortly conical protuberance from the ventral face of the thickened ectal section of the duct.

Two conjoined masses of tissue that protrude from the posterior margin of the brain are clearly distinguished from the rather greyish and smooth ganglion by a rough surface and strong iridescence.

Lymph glands of posterior segments are enlarged and filled with a brown, granular debris and small cysts of some parasite. Similar cysts were also present, in some cases, in the coelomic cavities.

These worms are "extraordinarily rich in vitamin B₁₂" (*in litt.*) according to Dr. Wm. J. Robbins (also 1951) who supplied some of them.

Spermatozoal iridescence is lacking on male funnels, in vasa deferentia and spermathecae, though the clitellum is sufficiently developed to indicate full sexual maturity. Even if sperm had been produced there would have been no normal way for it to be passed out of the body. The seminal vesicles have a rather juvenile appearance and the testes showed no evidence of discharge of sperm. All this, together with the fact that every specimen is completely anarsenosomphic, would seem to indicate that reproduction, in American individuals of the species, is parthenogenetic instead of sexual. The presence of normally developed spermathecae, as well as of seminal vesicles, may then indicate, in accordance with the principal of evolutionary economy, that the acquisition of parthenogenesis has been recent.

P. hilgendorfi was erected on seven specimens. One was sixthecal (No. 6) and one was monothecal (No. 7, with pore on 6/7), and both, as well as one quadrithecal worm, were without genital markings. Subsequently, sixthecal specimens, as well as dithecal (pores on 6/7-7/8), were referred to this species by its author. *P. hilgendorfi*, in agreement with various Japanese investigators, is considered to be primarily quadrithecal. Partial or complete disappearance of the spermathecal battery would not however be unexpected though apparently unrecognized hitherto by Japanese students. If genital markings also disappear along with the spermathecae, distinction of such individuals of *hilgendorfi* from similar mutants (without spermathecae and genital markings) of *P. agrestis* and *levis* will be impossible

until new criteria for specific identification have been developed.

P. hilgendorfi, except for a Korean record (Koryo and Keijo in Keiki-do), had not hitherto been recognized outside of Japan.

PHERETIMA HUPEIENSIS (Michaelsen) 1895

New Orleans, La., Jan. '42, 3 acitellate and 1 clitellate specimens.

E. Liebman, per Dr. G. E. Pickford.

New York City, deer corral in Zoological Park, spring of 1951, 21 medium-sized to large juveniles, 10 acitellate (at least five postsexual) and 1 clitellate specimens. July 2, 1951, 8 medium-sized to large juveniles, 11 acitellate and 2 clitellate (one early) specimens. Dr. C. W. Coates.

A greenish coloration mentioned by the collector was no longer recognizable externally when the New York worms were examined after formalin preservation but traces were still visible internally. The mid-dorsal longitudinal band was red. Spermathecal pore protuberances were lacking and sex organs were juvenile in the clitellate New York specimens. Rudiments of genital markings are recognizable even on the smallest juveniles and one had an extra pair on 16/17.

The typhlosome is a low lamelliform ridge less than one mm. high, beginning in the caecal segment and ending in lxxxviii (a clitellate specimen of 126 segments). A pre-typhlosolar ridge in xvi-xxvi is scarcely recognizable.

P. hupeiensis has been reported as a nuisance, because of casting deposition above ground, in "many" golf courses and country clubs but attempts to secure more data as to specific localities involved have been futile. Methods of control have been worked out at the Conn. Agr. Exp. Sta., New Haven (Schread, 1952).

The species has been established in the United States for forty years at least. It was collected in the District of Columbia in 1910.

PHERETIMA LEVIS (Goto & Hatai) 1899 ?

New York City, in the aquarium building at the Bronx Zoo, September 1947, 4 clitellate specimens. July 1950, 1 clitellate specimen. Dr. C. W. Coates. (From the tanks where worms were being raised to feed the platypuses.)

External characteristics. Length, 75-100 mm. Diameter, 5-7 mm. Segments, 88-97 (see under regeneration below). Dorsum pigmented, pigmentation red in the 1950 specimen, others reddish, brownish or

even grayish. Prostomium epilobous, tongue open.

The setae begin on ii, the circles with no marked, regular break mid-dorsally or midventrally: 28/ii, 30/iii, 35/iv, 48/viii, 47/xii, 48/xx, viii/20. First dorsal pore on 12/13 (5). Clitellum (annular) probably reaches to 13/14 and 16/17 but the dorsal pores of those furrows are not occluded.

Spermathecal pores minute and superficial, nearly $\frac{1}{2}C$ apart; on 6/7-7/8, two pairs (2 specimens), on right side only (1), on right side of 7/8 only (1). One specimen is athecal. The female pore is median (5).

Genital markings are quite small, circular tubercles, each with a single, central minute aperture. Two markings are usually close to each spermathecal pore, one in front and one behind, the posterior slightly more median to the spermathecal pore than the other. Post-clitellar markings are present on two specimens, in the setal circle of xviii and on the left side; one marking (athecal specimen), two markings (specimen with spermathecae on right side only).

Internal anatomy. Septa 8/9-9/10 lacking, none especially muscular. Intestinal origin in xv (5). Intestinal caeca manicate, dorsalmost secondary caecum the longest. Typhlosole low, lamelliform, with a few slight lateral ridges, gradually disappearing posteriorly, definitely lacking behind xlii (specimen with 88 segments), xlvii (92 segments), xlviii (94 and 97 segments), continued anteriorly from caecal segment into xx but gradually decreasing in size. Ventral typhlosole flat, ribbon-like and with a slight median groove, from first, second or third postcaecal through 15, 16, or 17 segments.

Last hearts in xiii (5). Left heart of ix present (3), right present (1), both hearts of ix present but that of the left side larger (1). Hearts of x lacking (5).

Testis sacs unpaired, the ventral blood vessel in roof of the sacs which are above the nerve cord. The sac of xi is U-shaped, with seminal vesicles of that segment apparently included (1, uncertain in other specimens). Testes disc-shaped to spheroidal. Seminal vesicles small and with primary ampullae. Vasa deferentia usually with a vesicular swelling in region of xv-xvii from which a filiform continuation is recognizable on or in the parietes for varying distances.

Spermathecae are fairly large. The duct has a marked muscular sheen, is about as long as the ampulla and is narrowed ectal to diverticular junction, which may be at the parietes or quite obviously more entally. The diverticulum is usually at least as long as the main

axis. The stalk is slightly slenderer than the duct and at least as long. The seminal chamber is of about the same length as the stalk, sausage-shaped or variously widened but never looped. The seminal chamber, and occasionally the ampulla also, contains an opaque material without iridescence.

Genital marking glands are stalked, the stalks short and confined to the parietes or longer and markedly protuberant into the coelomic cavities.

Regeneration. Short tail regenerates are present on four of the specimens: of two segments at 86/87, 90/91, and 94/95, of three segments at 91/92. The penultimate and antepenultimate segments of the other worm are about as long as those in front but are markedly narrower and have no setae. If these two segments were not regenerated they must have been recently developed in normal growth.

Remarks. Each specimen is anarsenosomphic and, being clitellate, presumably mature. As there is no indication of production of spermatozoa in any of these worms, reproduction probably would have to be parthenogenetic. Nevertheless, the opaque material present in spermathecal ampullae and seminal chambers may indicate that these particular individuals had, in spite of their inability to exchange sperm, gone through the form of copulating.

P. levis is known only from the original brief description of the Japanese types (number?, present location?). The species can be distinguished, for the present, from *P. hilgendorfi* by the absence of unpaired median patches of genital markings and by the presence of discrete markings near the spermathecal pores.

P. levis, *hilgendorfi* and *agrestis* are but three examples of species of the genus *Pheretima* in which evolutionary tendency has been in direction of obligatory parthenogenesis. With acquisition of ability to reproduce parthenogenetically most organs of the hermaphroditic reproductive system—the prostates and their ducts, copulatory chambers and associated porophores, penes and glands, the male porophores, male deferent ducts and their funnels, seminal vesicles, testis sacs, testes, spermathecae, and perhaps also genital markings and the glands associated therewith—presumably became almost or completely useless. In *P. diffringens*, which may prove to be parthenogenetic, prostate glands frequently are lacking (as in Nebraska specimens) though the ducts of such glands may be more or less normally developed. In American colonies of *P. agrestis*, *hilgendorfi* and *levis* all of the male terminalia are, usually at least, lacking. In other species

(in Japan, Burma, etc.) spermathecae are lacking, in some cases as well as the male terminalia.

The taxonomy of the genus *Pheretima* has been concerned mostly with reproductive structures. If then, along with such organs as spermathecae and male terminalia, characteristic genital markings also disappear in parthenogenetic forms, specific identification, in the present state of our knowledge, becomes impossible. Just that kind of a taxonomic puzzle has been presented by 18 specimens from three places: New York City (supplied by Dr. Coates), Kingston, and a New Jersey locality (supplied by Mr. Harold Davies). Each of these worms has manicate intestinal caeca. The only species of *Pheretima* with such caeca that are now known to be established in the continental United States are *agrestis*, *hilgendorfi* and *levis*.

PHERETIMA sp. I

Athecal and anarsenosomphic specimens are all rather small. Most are posterior amputees.

PHERETIMA sp. II

One anarsenosomphic worm has a single spermatheca that appears not to be normally developed. The aperture is located on 6/7 on the left side, but was invisible until after the cuticle had been peeled off. The long stalk of a coelomic gland passes into the parietes near the spermatheca but no genital marking is recognizable externally even after removal of the cuticle. This gland permits tentative identification of the worm as *P. levis*.

PHERETIMA sp. III

A transversely elliptical male porophore is present in the setal circle on the left side of xviii. A prostate gland is present on the left side and is unusually large, extending through segments xv-xx! The prostatic duct is bent into a hairpin loop the ectal limb of which is much thicker, but both limbs have a marked muscular sheen. The vasa deferentia of the left side pass into the ental end of the prostatic duct.

If this specimen had been in a pure culture it could have provided interesting information as to characteristics of the male terminalia in the ancestral form from which the anarsenosomphic type has been evolved.

PHERETIMA MORRISI (Beddard) 1892

- Poughkeepsie, N. Y., leaf pile below greenhouses of Vassar College, Aug.-Nov., 2 clitellate specimens. V. L. Fogerson, per Dr. G. E. Pickford.
- Poughkeepsie, N. Y., pile of dirt in unheated greenhouse of Vassar College, January, 8 clitellate specimens. V. L. Fogerson, per Dr. G. E. Pickford.
- Lutz, Florida, spring of 1950, 1 clitellate specimen. Dr. H. S. Hain, per Dr. C. W. Coates. (These worms were being raised for sale as bait, in a bed of muck and manure on white sand, in the shade of cypress trees.)
- Lutz, Florida, March 1951, 1 clitellate specimen. Dr. C. W. Coates.
- Negritos, Peru, Nov. 16, '39, 1 clitellate specimen. Mrs. H. Exline Frizzell per Dr. G. E. Pickford.

PHERETIMA RODERICENSIS (Grube) 1879

- Lutz, Florida, spring of 1950, 1 clitellate specimen. Dr. H. S. Hain, per Dr. C. W. Coates.
- Lutz, Florida, March 1951, 5 clitellate specimens. Dr. C. W. Coates.
- Sta. Anasco, Porto Rico, (probably in the western part of Aguadillo province), 1/20/99, 1 clitellate specimen. Porto Rico Expedition, Steamer Fish Hawk, 1898-99. (U. S. Nat. Mus.)
- Rio Piedras, Porto Rico, Sept. 16, 1945, 16 large juvenile and a clitellate specimens, 12 partially clitellate or clitellate specimens. (17 juveniles and posterior fragments presumably also of the same species.) Mr. R. Crespo per Dr. R. Kenk. (U. S. Nat. Mus. No. 184700.)
- Mt. Joy, Dominica, British West Indies, March 18, 1949, 4 clitellate specimens. Mr. Stephen Haweis.
- Mt. Joy, Dominica, British West Indies, compost heap, June 19, 1949, 1 juvenile, 1 a clitellate and 2 clitellate specimens. Mr. Stephen Haweis.
- Grahamstown, Eastern Cape Province, South Africa, "dug by gardener from lands above gardens, rich soil", 8/3/26, 4 clitellate specimens. Dr. G. E. Pickford.

External characteristics. Segments, 92, 95 (2), 96 (2), 97 (2), 98, 99 (2). Prostomium epilobous, tongue open. Setae begin on ii. The

circles have no marked or regular breaks mid-dorsally or midventrally. Numbers (Florida specimen): 21/ii, 32/iii, 35/iv, 36/viii, 49/xii, 48/xx. The clitellum (annular) of the Florida specimen did not quite reach 13/14 and reached to just behind the equator of xvi. Each spermathecal pore is at the center of a clearly demarcated, transversely elliptical, greyish translucent area and is in line with an intersegmental furrow but the translucent area appears to belong to the segment in front (Florida specimens).

Genital markings are lacking on three specimens, the posterior markings present on 30, the anterior only on one. The markings in some of these specimens appear to be squarely and equally across 18/19 but in others, especially in an early stage of development, appear to be definitely segmental and postsetal on xviii.

Internal anatomy. The typhlosole is lamelliform, about $1\frac{1}{2}$ mm. high, gradually decreasing in height posteriorly, ending abruptly in lxvi (worm of 92 segments), lxvii (95, 96, 96, 97 segments), lxix (97 segments), lxxi (99 segments), lxxii (95 segments). A lower ridge continues the typhlosole from the caecal segment into xv. From 52/53, in one specimen, the ventral margin of the typhlosole is scalloped and with definite pits under septal insertions as in *hilgendorfi*. A ventral typhlosole apparently is lacking. Hearts of x are present (3 specimens).

Regeneration. A tail regenerate at 88/89 is metamerically abnormal but with about five segments. Another tail regenerate, of two segments, is at 59/60. A small regenerate at 55/56 is metamerically undifferentiated and with terminal anus. The typhlosole of this worm is high from xlix anteriorly but rudimentary in l-liv and lacking in lv, and presumably has regressed, since amputation, in those segments. Several other worms probably have a tail regenerate of two or three segments only.

Remarks. The penultimate segment of several specimens has only a few setae ventrally, differentiation not yet having been completed. The anal segment of one worm has a well developed intersegmental furrow in the ventrum but setae are not yet visible in front of it.

P. rodericensis has not been reported previously from the mainland of the United States but probably has been widely distributed throughout the country in earth around greenhouse plants (Gates, MS). The center or centers of such distribution have not yet been discovered.

With addition of *P. bicincta* (E. Perrier) 1875, which probably has been similarly distributed with greenhouse plants, ten species of *Pheretima* are now known to have become established within the limits of continental United States.

Genus PONTODRILUS E. Perrier 1874
PONTODRILUS BERMUDENSIS Beddard 1891

Boca Chica, Texas, 4/2/38, 2 clitellate specimens. Mr. Ottys Sanders.

?

Marquesas, Florida, sand, June-July 1914, 51 specimens. A. L. Treadwell. (Am. Mus. Nat. Hist. No. 2181.)

External characteristics. Length, 59-62 mm. Diameter, 2.5 mm. (clitellar region and xvii). Segments, 98, 104. Spermathecal pores exactly on *b* lines, on tips of slightly conical protuberances. The left male pore is on xvii of one of the worms, the right on xix and the genital marking on 20/21 but xvii-xix may be involved in a spiral abnormality (intersegmental furrows not definite in the region involved).

Internal anatomy. Lamellae which may be calciferous are present in xiv-xvi and are especially pronounced in xv. The gut is widened in xvii but no definite valve was found. A sacculation of the intestine in xviii, on each side, is so marked as to have the appearance of a caecum. Nephridia of xiv are lacking. Those of xiii, xv-xvii are large, the surfaces with a finely granular appearance. The caliber of the nephridial tube decreases in xviii-xx, and from xxi posteriorly the large flattened sac is recognizable. The spermathecal diverticulum apparently passes into the body wall some distance from the point of entry of the duct.

External characteristics (Marquesas specimens). Spermathecal and male pores are on the *b* lines.

A pair of small, circular, greyish translucent areas is present in *aa* on xviii (except in two worms), the areas nearly symmetrically placed across the setal arc. Both areas, on some of the specimens, are on a single transverse area of marked tumescence. The grey areas of another specimen are in contact mesially and on a ridge which also includes the slightly depressed male pores. The whole median region (of *aa*) of two specimens (with indications of clitellar glandularity) is greyish translucent, slightly depressed and surrounded by a rather conspicuously protuberant white rim.

A median genital marking is present on 19/20 on at least 41 of the specimens, and is clearly marked off into an opaque marginal band and a grey, translucent central portion.

Internal anatomy. The deferent duct passes into the ental end of

the prostatic duct. The latter has no muscular sheen and is in two short, u-shaped loops which are bound to the parietes. The single, shortly digitiform diverticulum passes into the median face of the spermathecal duct well above the parietes and may have several translucent spots suggestive of discrete but empty seminal chambers.

Remarks. None of the Marquesas specimens is sexual and the spermathecae appear to be in various stages of late juvenile development.

The spermathecal pores are in the *bermudensis* rather than the *gracilis* location but the diverticulum passes into the spermathecal duct well up from the body wall in the coelomic cavity as in *gracilis*. Grey areas on xviii presumably represent an early stage of development of a median part of the male field.

PONTODRILUS GRACILIS Gates 1943

Punta Garda, Florida, 3 juvenile and 2 a clitellate specimens.

J. C. Galloway per U. S. Nat. Mus. (1 long intestinal fragment and 8 tail pieces may be of the same species.)

Spermathecae are fairly well developed in the two a clitellate specimens, the single, median diverticulum passing into the duct quite definitely ental to the parietes.

These specimens were labelled as, "Found in beach sand between tides, putting up castings after the fashion of *Lumbricus*".

IV

Family MONILIGASTRIDAE

Genus DRAWIDA Michaelsen 1900

DRAWIDA BAHAMENSIS (Beddard) 1892

Cidra, Porto Rico, "Treasure Island", 1,200 feet, September 3, 1945, 1 a clitellate specimen. Dr. R. Kenk. (U. S. Nat. Mus. No. 184700.) A posterior fragment of another individual may be of the same species.

External characteristics. Length, ca. 20 mm. Diameter, ca. $1\frac{1}{2}$ mm. Segments, ca. 110. Pigmentation lacking (? alcoholic preservation). Prostomium probably probolous, deeply retracted. Setae begin on ii; closely paired, *ab* ca. = *cd*, *aa* slightly < *bc*, *dd* ca. = $\frac{1}{2}$ C. Nephropores large and readily recognizable from iii posteriorly, in *cd* or on *d* lines.

Spermathecal pores just median to *c* lines, on 7/8. Female pores on xii, just behind 11/12, about on *b* lines. Male pores on 10/11, in middle portion of *bc*.

Genital markings are two pairs of indistinctly demarcated, transversely placed areas of tumescence, with smooth surfaces and no indication of differentiation of central and marginal portions, in *ad*. postsetal on *x* and presetal on *xi*.

Internal anatomy. Septa 5/6–8/9 thickly muscular. Gizzards in xii–xiv. Gut valvular in xviii.

Testis sacs apparently are restricted to *x* (?) The vas deferens, probably fairly long, and entirely in *x* (?), is coiled into a tight ball of loops that is of about the same size as the sac immediately above it. The prostate comprises a quite small, spheroidal, acinous mass into which the vas passes, connected by a very short and slender neck to a larger, thick-walled spheroidal body that is protuberant into the coelom. This body, which has a muscular sheen, has on its roof a shortly digitiform penis.

The spermathecal duct is looped and passes into the ental end of a shortly digitiform atrium erect in viii that is about twice the thickness of the duct. The ovarian segment probably is reduced to a horse-shoe-shaped ovarian chamber. Ovisacs are juvenile and confined to xii.

Remarks. This species has been known hitherto from two specimens supposedly imported to Kew from the Bahamas.

The family Moniligastridae is oriental. Very few cases of transportation have been recognized and all have been in the genus *Drawida*. As yet there have been no records of any species from the continental United States.

D. bahamensis may have come originally from some part of China.

V

Family ACANTHODRILIDAE

Genus DICHOGASTER Beddard 1888

DICHOGASTER sp.

Luquillo National Forest, Porto Rico, April 4, 1943, 1 small juvenile. Dr. R. Kenk. (U. S. Nat. Mus. No. 184700.)

Rio Piedras, Porto Rico, September 16, 1945, 1 juvenile and 2 clitellate specimens. Mr. R. Crespo per Dr. R. Kenk. (U. S. Nat. Mus. No. 184700.)

Remarks. Juveniles of *Dichogaster* sp. have been intercepted, on

various occasions, in shipments of plant material into the United States.

Two species have been recorded from California: *D. bolawi* (Michaelson) 1891 (San Francisco) and *D. saliens* (Beddard) 1893 (Del Monte and San Francisco). Peregrine species of *Dichogaster* are all small and may have been overlooked in other localities.

Genus *MICROSCOLEX* Rosa 1887

MICROSCOLEX DUBIUS (Fletcher) 1887

Ruston, Louisiana, yard of apartment house, March 1951, 3 clitellate specimens. Mr. Walter Harman.

Canberra, Australia, drainage ditch between row of poplars and Cupressus hedge, 1 clitellate specimen, per Dr. N. Tebble.

Remarks. These worms are fairly large for this species, 47–65 mm. long, 3–4 mm. thick. Segments, 114–116. The cuticle turns into the gut at the mouth and is recognizable back to level of 6/7. A supra-oesophageal trunk is recognizable in ix–xiii but no subneural was found. The dorsal trunk passes forward under the brain. Hearts, in x–xii, are large and apparently latero-oesophageal. Commissures of ix–v are lateral. There are no spermathecae but on 6/7–8/9, on the *a* lines, a minute greyish marking is present which was thought, until after study of internal anatomy, to represent a rudimentary spermathecal pore.

This is the first record from Louisiana, but the species has been reported from California (San Francisco, Berkeley, Santa Rosa, Santa Barbara, Mt. Diablo) and North Carolina (Raleigh). Other records: Mexico, Chile, Argentina, Uruguay, France, Cephalonia, Balearic Is., Madeira, Canary Is., Algiers, Tunis, South Africa, Australia (South-west Australia, South Australia, New South Wales, Tasmania), Norfolk Island, New Zealand.

MICROSCOLEX PHOSPHOREUS (Duges) 1837

New Orleans, Louisiana, park, June 1942, 1 clitellate specimen in poor condition. Mr. E. Liebman per Dr. G. E. Pickford.

Bangor, Maine, greenhouse, February 28, 1953, 2 clitellate specimens.

Remarks. Genital markings are postsetal, on xi, the centers about on the *a* lines. The gut is valvular in xv, moniliform in ix–xiv, the

sections in xiii-xiv small but larger than that in xv, much larger in ix-xiii. On the floor of the gut in ix-xiii there is a low longitudinal ridge with a slight groove at the median plane (2). Each spermatheca (Bangor specimens) has two diverticula, one to the median and the other to the lateral side of the duct.

This species had previously been recorded from Washington (D. C.), North Carolina (Raleigh), Florida (Quincy), and California (San Francisco, Coulterville, Redding, Santa Barbara, Santa Rosa, Lake Chalot, Alameda County). Other records: Mexico, Brazil, Paraguay, Argentina, Chile, Germany, Switzerland, France, Italy, Sardinia, Algiers, Canary Is., South Africa, New Zealand.

M. phosphoreus, like *M. dubius*, may have come originally from the extreme southern part of South America.

Genus TRIGASTER Benham 1886

TRIGASTER sp.

Luquillo Forest, Porto Rico, 1,800 feet, September 22, 1945, 1 juvenile. Sept. 22, 1947, 1 specimen. Dr. R. Kenk. (U. S. Nat. Mus. No. 184700.)

External characteristics. Length, ca. 40 mm. (juvenile specimen). Diameter, ca. 1.5 mm. Pigmentation red (not leached in spite of alcoholic preservation, but formalin fixation). Prostomium tanylobous. Setae begin on ii; *ab* much smaller than *cd* throughout, *dd* ca. = $\frac{1}{2}C(?)$. First dorsal pore on 5/6.

Internal anatomy. Gizzards, three, possibly in vi-viii. Gut in next segment but one behind last gizzard, and through two or three segments widened, with numerous, closely crowded, white, circular, thin and lamelliform ridges on inner wall. Excretory system micro-nephridial.

A bundle of (penial?) setae is conspicuously protuberant into the coelomic cavity on each side of xvii (?) and xix (?). The setae are not sigmoid and taper to a rather pointed tip and appear to be unornamented.

Remarks. Genital organs were not found. The specimen is in too poor condition to permit further characterization.

The 1947 specimen is 155 x 5 mm. In spite of anesthesia and preservation in alcohol the red pigmentation is still recognizable. Maceration is too advanced to permit determination of other external characteristics. Two pairs of fairly large nephridial clusters are

present in segments in front of the first gizzard. Four pairs of hearts are present behind the last gizzard segment.

Species of *Trigaster* have been recorded hitherto only from St. Thomas and Mexico. All of the species are in need of more adequate characterization. The Porto Rican form is distinguishable from the Mexican by the presence of a third gizzard, and from the St. Thomas species by the bright pigmentation, presence of penial setae, and a more anterior location of the first dorsal pore. Little importance can be attached, at present, to any of these distinctions, since nothing is known as to intraspecific variation in gizzard number in the genus and penial setae have occasionally been said to be absent in species (of other genera) that do have them. If, however, presence of a third gizzard, and of penial setae, prove to be valid criteria of specific distinctness the exotic label (implied by inclusion in this contribution) may have to be removed.

VI

Family OCNERODRILIDAE

Genus *EUKERRIA* Michaelsen 1935

EUKERRIA PEGUANA Gates 1942

Rio Piedras, Porto Rico, September 16, 1945; 2 clitellate specimens. Mr. R. Crespo, per Dr. R. Kenk. (U. S. Nat. Mus. No. 184700.)

Remarks. Because of the poor condition the relative size of setal intervals *aa* and *bc* could not be determined. The genital marking is on *xxi* (1, lacking on the other specimen).

The spermathecal duct (coelomic portion) is about as long as the ampulla and is widened ectally. This widened portion contains an ovoidal mass of spermatozoa.

The finding of this species (hitherto known only from Burma) in Porto Rico confirms a prediction implicit in the inclusion of the original description in a contribution on peregrine forms.

The original home of this species presumably is somewhere in the southern part of South America.

EUKERRIA SALTENSIS (Beddard) 1895

Dayton, Oregon, hopyard, gravel bar below woods, Willamette River, June 4, 1948, a number of specimens. Mrs. Dorothy

McKey-Fender.

Remarks. These well preserved specimens had already been identified by Mrs. McKey-Fender.

This is the first record of this species from the continental United States. "In origin it is undoubtedly South American" (Pickford, 1928, p. 379). It has been recorded from the following places: Chile (Salto, Quillota, Coquimbo, Valparaiso). Easter Island. South Africa: Cape Province (Stellenbosch), Natal (Durban, Horwick), Transvaal (Pretoria, Johannesburg). Burma (Pinyinmana, Monywa). Australia: New South Wales (Sydney, Paramatta, Mt. Victoria). New Caledonia (Oubatch).

Genus GORDIODRILUS Beddard 1892

GORDIODRILUS PEGUANUS Gates 1942

Rio Piedras, Porto Rico, September 16, 1945, 5 clitellate specimens. Mr. R. Crespo per Dr. R. Kenk. Several other specimens may be of the same species. (U. S. Nat. Mus. No. 184700.)

Remarks. The condition does not permit determination of relative sizes of setal intervals *aa* and *bc*. The clitellum apparently extends only between the setal arcs of *xiii* and *xix*. Male and prostatic pores are unrecognizable.

Although testes are present in both *x* and *xi*, seminal vesicles again are present only in *xii* and are small. Several transparent chambers are present about at the middle of the coelomic portion of each spindle-shaped spermathecal duct but, as in the Burmese and Indian specimens, are empty.

This record confirms a prediction implicit in the inclusion of the original description of this species in a contribution on peregrine forms (Gates, 1942).

G. bonacanus Cernosvitov 1942 is distinguished from *peguanus* only by characteristics that may be explainable as due to incomplete development, individual variation, or misinterpretation of conditions in rather difficult material. *G. peguanus* has priority (February over June).

Although *G. peguanus* is known today only from Burma (Amherst, Thaton, Hanthawaddy, Insein, Minbu and Katha districts), India (Bangalore), Bonaco Island (in the Caribbean) and Porto Rico, the original home of the species must be somewhere in Africa.

OCNERODRILUS sp.

Luquillo Forest, Porto Rico, Recreation area, 1,800 feet, September 1, 1945, 8 specimens. Dr. R. Kenk. (U. S. Nat. Mus. No. 184700.)

External characteristics. Length, to ca. 35 mm. Diameter, ca. 1 mm. Pigmentation unrecognizable (alcoholic preservation). Prostomium epilobous, ca. $\frac{1}{2}$, tongue narrowed posteriorly. Setae begin on ii; ab ca. = cd , $aa < bc$, $dd < \frac{1}{2}C$, a and b of xvii apparently lacking. Clitellum, on xiv-xviii (+?), apparently saddle-shaped, lacking in ce ventrally or a smaller portion of that interval.

Spermathecal pores were not seen but apparently are on 8/9 in region of ab . Female pores on xiv, on b lines. Male pores (?) on xvii, about on b lines. The immediate margin of each pore may be slightly tumescent and whitened.

Internal anatomy. Septa 7/8-8/9 rather thickly muscular, 6/7 with less marked muscularity. No gizzard. Calciferous glands paired, in ix, elongately ellipsoidal, the anterior end of each attached by a short cord to the posterior face of 8/9, the posterior end attached to the ventral face of the gut just in front of 9/10, the walls rather thick, the lumen central and longitudinal. Intestinal origin in xii. No typhlosole. Hearts large, in x and xi.

Holandric, testes and funnels apparently free in x and xi the coelomic cavities of which are however narrowed by approximation of the septa. The coelomic cavities of x and xi are filled with a white material apparently composed of compacted coelomic corpuscles. Seminal vesicles are acinous, those of ix small, those of xii united into a rather horseshoe-shaped mass (3 specimens).

The prostates are of variable length, confined to xvii, extending into xviii, long enough to reach through three or four segments. The deferent duct lies just lateral to the ectal end of the prostatic duct and apparently passes into the parietes on the posterior face of the prostatic duct without widening.

The spermathecae are small. The ampulla is nearly spheroidal but with small lobulations entally. The duct is very slender and much shorter than the ampulla.

Remarks. The condition is only fair and does not permit certainty with respect to some important external characteristics. As only one pore was recognized on each side of xvii, it is assumed that the prostatic and deferent ducts unite in the body wall. Although clitellar

glandularity was recognizable on certain segments no spermatozoal iridescence was noted anywhere. Accordingly, it is uncertain whether the clitellum and certain other organs such as the prostates and spermathecae are fully developed.

The species clearly belongs to a group that has been recognized (Stephenson, 1930) as of subgeneric status, *Ilyogenia* Beddard 1893. in which specific distinctions rest largely on characters such as: presence or absence of ventral setae of xvii, presence or absence of clitellar glandularity on ventrum, segmental extent of clitellum, size of prostates, *i. e.*, characters that either are known to change during growth, or that may be suspected of undergoing such changes. In these circumstances, and in absence of certainty that development had been completed in the Porto Rican specimens, specific identification scarcely seems feasible. However, the single horseshoe-shaped seminal vesicle of xii now appears to be unique in the genus.

The only species of *Ocnodrilus* previously known from the West Indies, *O. calwoodi* Michaelsen 1899, has been reported from two localities, St. Thomas and Havana, Cuba. (Thirteen of the eighteen North American species are known only from the original descriptions of fifty or more years ago, or only from the original specimens, in either case from a single locality.) Another "American" species, *O. occidentalis* Eisen 1878 has been carried around the world. The Luquillo form, whatever it may eventually prove to be, is regarded tentatively as an exotic in Porto Rico.

VII

Family HORMOGASTRIDAE

Genus HORMOGASTER Rosa 1887

HORMOGASTER REDII Rosa 1887

In "soil with citrus tree, in baggage from Italy arriving on S/S La Guardia at New York, Nov. 8, 1950, 2 clitellate specimens. Dr. C. W. F. Muesebeck.

External characteristics. Length, 112-122 mm. (+? posterior end lacking?). Diameter, 10-12 mm. Segments, *ca.* 254-317 (+?). Segment length increases through i-ix, decreases through x-xv, is very short from xvi and from xxviii posteriorly still shorter. Numerous furrows extend from the anterior end of the body to 2/3 and are about equally spaced in both dorsum and ventrum. A well marked secondary furrow, on the dorsum only, is present on each of ix-xii. The dorsum

has a grey or slate color that is darker in the clitellar region. The prostomium is probolous (2 specimens). (No dorsal pores.)

Setae are small: on iii-x *a* and *b*, when recognizable, are very closely paired, from xi *a* is increasingly more median until greatest separation is reached on xiv or xv; *c* and *d*, usually lacking (?) on ii-xvii or xviii, are very closely paired throughout the rest of the body. Behind the clitellum *ab* is somewhat smaller than *bc* which is smaller than *aa*, $dd < \frac{1}{2}C$. Apertures of the *a* and *b* follicles of xviii-xxviii are enlarged, slit-like or comma-shaped, diagonally placed. The apertures of the *a* and *b* follicles of xii-xiv are also somewhat enlarged.

Nephropores are large, first recognizable on iii (2) and are slightly above the *b* lines, in a regular longitudinal rank on each side, probably close to the midlateral line.

The clitellum has rather indistinct boundaries but apparently is annular, extending from the posterior half of xii to 27/28 (or 28/29?), or the posterior half of xiii to 26/27 (+?). The epidermis is not much thickened and intersegmental furrows are not obliterated (grooves containing the furrows apparently as deep here as posteriorly).

Spermathecal pores are minute, three pairs, on 9/10-11/12 (2), dorsal to the nephropore ranks. An extra pore, on 10/11 of one specimen, is median to the normal location. The female pores, about as large as the nephropores, are on the posterior half of xiv, about in line with the male pores and somewhat median to the nephropore lines. Male pores are almost as small as the spermathecal and are on 15/16, slightly median to the nephropore lines. The male tumescences are well developed, horseshoe-shaped, transversely placed on xv-xvi, with open end laterally, 15/16 obliterated on the median portion.

A broad band of whitening (and especial epidermal tumescence?) extends along xviii-xxviii from just median to the *a* lines to just lateral to the nephropore lines. Midway between *a* and *b* lines the whitening may be less obvious or lacking (1). The lateralmost portion on xviii or xix to xxiv or xxv is slightly more protuberant and marked off by a slight median groove as an intersegmentally interrupted, low, rounded ridge possibly equivalent to a tuberculum pubertatis.

Internal anatomy. Septa 6/7-9/10 are thickly muscular. The gizzards are large, in vi, vii, viii, separated from each other by much weaker sections of the gut. The post-gizzard portion of the oesophagus has a white wall, rather smooth internally, is bent (almost looped) and irregularly contracted, definitely and gradually widened in the last two segments (xix-xx or xx-xxi?). A very short portion just in front

of the last two segments apparently is valvular. Calciferous lamellae were recognizable in the terminal portion of the oesophagus, in one specimen, in an intramural gland that was nearly circumferential (no openings into gut recognized). The typhlosole begins in the region of xxiii, completely fills the gut lumen, and ends abruptly in the region of cxcv (1). Anteriorly the typhlosole is composed of seven thick lamellae, of which the lateral three on each side join dorsally before uniting with the median lamella. Posteriorly the ventral margin of the typhlosole is rounded, smooth, and with no trace of longitudinal lamellation but the tissues are separable into very thin transverse lamellae.

The dorsal blood vessel is single and passes into the tissues of the pharyngeal bulb slightly behind the cerebral ganglia. The ventral trunk bifurcates just above the suboesophageal ganglia. The supra oesophageal trunk passes into the tissues of the pharyngeal bulb near the posterior margin and is free from the gut in v-ix or x, immediately underneath the dorsal trunk. Hearts of ix-xi are lateral and moniliform. The commissures of viii are nearly as large and moniliform dorsally but, like the smaller commissures of vi-vii, become very slender ventrally, the length of the slender portion increasing from viii anteriorly. Just beneath the boundary between the thick and the slender portions a fairly large vessel passes off and along the mesentery from the heart to the posterior septum. (The mesenterial vessels pass directly into the ventral trunk in x, but in ix into the hearts just prior to the junction with the ventral trunk). Commissures of v are present and a small vessel from the dorsal trunk on each side may represent a portion of commissures belonging to iv.

Holandric, testes and funnels in x-xi, the funnels rather large and polyplicate. Seminal vesicles are acinous, in xi and xii.

Spermathecal ampullae are nearly spheroidal, the duct practically restricted to the parietes. Oviduct funnels are transversely elliptical discs flattened against 13/14. A small organ on the posterior face of 13/14 just behind each oviducal funnel presumably is an ovisac (containing a small brown body).

Remarks. The depth of the grooves between the segments externally, and the looping of the nerve cord show that both of these worms are strongly contracted. This contraction would then be responsible for the irregularities and bending of the postgizzard portion of the oesophagus, as well as of divers portions of the intestine. The gut was completely empty. If these specimens had been taken in

diapause they must have straightened out during preservation. Hearts, ventral and dorsal trunks were filled with blood, as was the supra-oesophageal back into ix or x. Subneural and other trunks were unrecognized, like a posterior portion of the supra-oesophageal, presumably because they were empty. Nephridial bladders were collapsed and empty.

A grey-translucent marking on the intersegmental furrow (5/6-7/8) just below the nephropore lines, looks very much like a pore but no aperture was recognizable under the highest power of the binocular.

The foramen between the circumoesophageal nervous commissures measured 1.5 (dorsoventrally) by 1 (right-left) mm.

Both specimens had copulated, as was indicated by marked spermatzoal iridescence in the spermathecal ampullae but none was visible on the male funnels nor was there any coagulum in the coelomic cavities of x-xi.

The longitudinal white band present ventrally on each side of the clitellum apparently comprises genital tumescences surrounding modified setae, as well perhaps (laterally) as a tuberculum pubertatis. Such structures, together with the indistinctly demarcated but well developed tumescences around the male pores, are common in the Lumbricidae. In fact, Stephenson (1930, pp. 720-721) was inclined to believe that *Hormogaster* should be included in the family Lumbricidae because of the presence of "characteristic grooved genital setae" and since it is distinguished merely by "the multiplication of gizzards" which was regarded as "only of generic or at most of subfamily importance". The location of the gizzards in the oesophagus instead of the intestine, the strict metamerism of the gizzards¹, the posterior extension of the oesophagus behind xiv, absence of calciferous glands in xi-xiii (where they are located in the Lumbricidae), presence of a calciferous gland (in xx?) at the hind end of the oesophagus, perhaps also the peculiar typhlosole and the peculiar nephridial vesicles, should be taken into consideration as well as grooved setae.

Two species usually have been recognized, each with varieties, forms or subspecies. None of them seems to have been available in long series to permit study of variation. Some doubt has been expressed as to the distinctness of the two "species".

Hormogastrids have been reported from Italy (Samnium, Rome,

¹ The gizzard muscularity frequently extends through two or three segments in the Lumbricidae, but without separation into distinct metameric components.

Naples), Corsica, Sardinia (Cagliari and Siliqua), Sicily (Taormina, Palermo), Spain (provinces of Tarragona, Lerida, Basedona), Tunis, Algeria.

VIII

Family CRIODRILIDAE

Genus CRIODRILUS Hoffmeister 1845

CRIODRILUS LACUUM Hoffmeister 1845

Remarks. This species was collected some years ago, according to information kindly supplied by Mrs. Dorothy McKey-Fender, from some locality in the eastern states. This should indicate that the species already had become established in this country prior to that time, and presumably after transfer from some part of that area where it is known: Germany, Austria, Hungary, Italy, south Russia, Syria and Palestine. Increased pollution of waters in which the worms were living, resulting in extermination of the entire colony, may explain, in part, absence of any records in the literature.

C. lacuum is one of the few species that can replace, in anterior regeneration, the entire pre-intestinal portion of the body and including functional gonads of both sexes.

IX

Family LUMBRICIDAE

Peregrine species of this family probably have been established in the United States for 150 years or more. Accordingly, it is not surprising that by 1832 four of them were so common around Bangor, Maine, as to be considered "native" there. More recently, however, some of these same species have been characterized as "native" or "endemic" in scientific publications¹.

¹ *Lumbricus rubellus* "is, in the writer's opinion, our most common endemic earthworm west of the Cascade Mountains. It is found in almost every location in this section where any earthworms are found." (Altman, 1936, p. 95)

The lumbricid earthworms of Connecticut, none of them endemic there, are collectively distinguished from the more recently recognized "oriental earthworm", *P. hupeiensis*, as "native". (Schread, 1952)

Eighteen lumbricid species are exotic anywhere on the continent of North America.

- Allolobophora arnoldi* Gates 1952
- “ *caliginosa* (Savigny) 1826
- “ *chlorotica* (Savigny) 1826
- “ *limicola* Michaelsen 1890
- “ *longa* Ude 1885
- Dendrobaena mammalis* (Savigny) 1826
- “ *octaedra* (Savigny) 1826
- “ *rubida* (Savigny) 1826
- “ *subrubicunda* (Eisen) 1874
- Eisenia foetida* (Savigny) 1826
- “ *rosea* (Savigny) 1826
- “ *hortensis* (Michaelsen) 1890
- Eiseniella tetraedra* (Savigny) 1826
- Lumbricus castaneus* (Savigny) 1826
- “ *rubellus* Hoffmeister 1843
- “ *terrestris* L. 1758
- Octolasion lacteum* (Orley) 1881
- “ *cyaneum* (Savigny) 1826

Allolobophora iowana Evans 1948, considered by its author to be endemic in Iowa, is difficult to distinguish from the long-known *caliginosa*, and may have been the form primarily responsible for the conclusion that there really are no old species in the United States but only recently introduced forms “rapidly changed from their European progenitors” (Muldal, S. 1952. The chromosomes of the earthworms. *Heredity*, 6, p. 56.)

Among these lumbricid exotics probably are included those species most frequently introduced deliberately, in the past, into previously unentered areas. Records of several such introductions have been found in non-scientific as well as scientific publications, but for each of those instances there must be others about which information would be as welcome as that just received from Prof. Miller. According to this report, which was taken from Prof. Störer’s file: “In 1913 Dr. J. O. Snyder sent about 100 specimens of the common large earthworm of the eastern United States from Washington, D. C. and the animals were planted in the Memorial Court at Leland Stanford Junior University. The species was still present there, in living condition, in 1931.”

Colonization, in the United States, by three of the species, *A. arnoldi* (Gates, 1952a), *A. limicola* (Gates, 1953a) and *D. mammalis* (Davies, 1954) has been recognized only recently. Already, however, two of the three have been obtained at additional localities some distance

from the site of the original find (Davies, 1954 and Gates, 1952b). Several species that might have been expected, as well perhaps as others, possibly are awaiting discovery.

ALLOLOBOPHORA CALIGINOSA (Savigny) 1826

Juneau, Alaska, about ten miles to the north, in soil of an abandoned Indian village site (locally known as the Auke village site, in Auke Bay), September 11, 1950, 3 clitellate specimens. (11 juveniles of similar habitus presumably are of the same species.) H. J. Lutz and R. F. Taylor.

These earthworms, and those mentioned below, were the only ones found, according to Dr. Lutz, while sampling soils in Alaska. The site was covered with a very rank vegetation, mostly nettles (*Urtica* sp.) six to seven feet tall, and the soil was rich and gravelly.

LUMBRICUS RUBELLUS Hoffmeister 1843

Juneau, Alaska, about ten miles to the north, in soil of an abandoned Indian village site (locally known as the Auke village site, in Auke Bay), September 11, 1950, 1 clitellate specimen. (3 juveniles of the same habitus presumably are of the same species.) H. J. Lutz and R. F. Taylor.

Earthworms have not hitherto been recorded from the mainland of Alaska, though there has been one record of quite another species from Behring Island.

Presence of *L. rubellus* and *A. caliginosa* in Alaska undoubtedly is the result of an accidental introduction, and presumably involving transfer of soil containing live worms and/or cocoons.

X

DISCUSSION

Earthworms probably have been imported accidentally into this country ever since the first permanent European settlements. These animals are being so imported still, according to data secured in an investigation that has been under way for several years. In addition, they are being deliberately introduced, if certain advertisements are truthful, from various foreign sources. Many of the accidentally imported species probably never became established and, except in quite unusual circumstances, will remain unknown. Nevertheless, a total of forty-five species in eighteen genera, belonging to nine of the twelve families (Table) are now known to have reached the United States

Table
Exotic species of earthworms already found in the
United States, including Porto Rico

Family	Genus	Number of species	Remarks	
Alluroididae				1
Moniligastridae	Drawida	1	Porto Rico only.	+?
Oenerodrilidae	Eukeria	2	1 from P. R. only.	
	Gordiodrilus	1	Porto Rico only.	+?
	Oenerodrilus	2		+?
Acanthodrilidae	Microscolex	2		
	Dichogaster	2		+?
Megascolecidae	Pheretima	11	1 from P. R. only.	+? 5
	Pontodrilus	2		+?
Eudrilidae	Eudrilus	1		
Glossoscolecidae	Pontoscolex	1		
Sparganophilidae			Species endemic in North America.	
Microchaetidae				2
Hormogastridae	Hormogaster	1		3
Criodrilidae	Criodrilus	1		4
Lumbricidae	Allolobophora	5		+?
	Eisenia	3		+?
	Eiseniella	1		
	Dendrobaena	4		
	Octolasion	2		
	Lumbricus	3		+?

+? Other species of the genus known to be peregrine and possibly to be expected either on the mainland or in the Caribbean possessions.

¹ The Alluroididae has not been recorded from any place outside of Africa.

² One species of the Microchaetidae, *Glyphidrilus papillatus* (Rosa) 1890, has been regarded as peregrine but outside of Burma, where it may be endemic, has been reported only from India (Lucknow and Saharanpur) and the island of Hainan.

³ No evidence has yet been found to indicate that *H. redii* was ever established in the United States or anywhere outside of the Mediterranean lands.

⁴ *C. lacuum* may have become extinct in this country.

⁵ *P. elongata* (E. Perrier) 1872, has not yet been found on the mainland.

The families are those of Michaelsen's classification of 1921 (Arch. Naturg. 86-A) except for omission of the Syngenodrilidae (probably belongs in the Alluroididae) and elevation of the acanthodrilid Oenerodrilinae to independent status. Only six families were recognized in "The Oligochaeta" (London, 1930) though Stephenson was inclined "to regard the Oenerodrilinae as more entitled to independent status" (p. 720).

(including Porto Rico) from sources ultimately in Europe, Africa, Asia, and South America, all the continents except Australia. Most of those species appear to be permanently established on the mainland.

Some of the exotic forms are being raised every year in hundreds of thousands, perhaps millions (if the claims of the "earthworm farmers" are correct), for sale to "organic" gardeners and farmers (for cultivating and enriching the soil) and to anglers who can be expected to scatter them even more widely. Some exotic forms have been distributed through the mainland from Maine to California with greenhouse plants and must have escaped frequently from retail greenhouses, occasionally at least to work their way from urban centers into more rural areas and thence even into the forests. Adherents of the "organic" cult of gardening and farming have been urged for several years to make use of techniques that are claimed to result in increase in number of earthworms. but only, so far as is known, of the exotic kinds. These species, rigorously selected from so many different generic types, have been in competition, in much of the country, with native forms.

The endemics of the mainland, all the way from the Mexican border to the Arctic, belong to *Sparganophilus* (Sparganophilidae), *Eisenia* and *Bimastos* (Lumbricidae), *Plutellus* and *Megascolides* (Megascolecidae, and Pacific coast area only), *Diplocardia* (Acanthodrilidae) — only six genera of four families. Species of *Diplocardia* have never been found outside of this continent, even as a result of accidental transportation. Yet one way restriction on accidental transportation seems highly improbable. Failure of any of our American species to colonize those foreign regions to which they were transported must then have been due to lack of some or all of those characteristics that enable exotic forms to become established here.

SUMMARY

Eukerria saltensis (Ocnerodrilidae), *Pheretima bicincta*, *hilgendorfi*, *levis* and *rodericensis* (Megascolecidae), *Eudrilus eugeniae* (Eudrilidae), *Pontoscolex corethrurus* (Glossoscolecidae), *Hormogaster redii* (Hormogastridae), *Criodrilus lacuum* (Criodrilidae), are reported for the first time from the mainland, *P. hilgendorfi* and *levis* for the first time outside of Japan-Korea, *H. redii* for the first time outside of Mediterranean lands. *Drawida bahamensis* (Moniligastridae), previously known only from the types, *Gordiodrilus peguanus*, *Eukerria peguana*, *Ocnerodrilus* sp. (Ocnerodrilidae), *Trigaster* sp. (Acanthodrilidae), *E. eugeniae* and *P. corethrurus* are reported for the first time from Porto Rico, seven of the nine species now known from there certainly exotic.

Among further new records are those of *Microscolex phosphoreus* in New England, and of two lumbricid species in Juneau, the first earthworms reported from the Alaskan mainland. Two-tailed specimens of *Eudrilus eugeniae* are reported for the first time and a record of one with a third caudal axis is the first for any adult, unregenerate earthworm. *P. agrestis*, *hilgendorfi* and *levis* being anarsenosomphic must reproduce parthenogenetically, as perhaps *P. diffringens* may also. Athecal, anarsenosomphic individuals of these species are not at present identifiable. Forty-five species of eighteen genera of nine of the twelve families of earthworms are now known to have reached the United States, presumably during the last 350 years, from sources ultimately in Europe, Africa, Asia and South America. Most of these species are now permanently established on the mainland. American endemics apparently lack those characteristics that enable the exotics to become established here.

REFERENCES

ALTMAN, L.

1936. Oligochaeta of Washington. Univ. Washington Pub. Biol., **4**: 1-137.

BAHL, K. N.

1942. Studies on the structure, development, and physiology of Oligochaeta. III. The branching and division of nephridia and Eisen's so-called 'safety valves' in *Pontoscolex*. Quart. Jour. Micros. Sci., **84**: 1-17.

DAVIES, H.

1954. A preliminary list of the earthworms of northern New Jersey with notes. Breviora, **26**: 1-13.

GATES, G. E.

1942. Notes on various peregrine earthworms. Bull. Mus. Comp. Zool., Harvard, **89**: 64-144.
1943. On some American and Oriental earthworms. Ohio Jour. Sci., **43**: 87-98.
1952a. New species of earthworms from the Arnold Arboretum, Boston. Breviora, **9**: 1-3.
1952b. On the earthworms of New Hampshire. Breviora, **10**: 1-3.
1953a. On the earthworms of the Arnold Arboretum, Boston. Bull. Mus. Comp. Zool. Harvard, **107**: 499-534.
1953b. Further notes on the earthworms of the Arnold Arboretum, Boston. Breviora, **15**: 1-9.

PICKFORD, G. E.

1928. Synonymy in the genus *Kerria*. Ann. Mag. Nat. Hist. (10),
11: 378-383.

ROBBINS, W. J. et al.

1951. Further observations on *Euglena* and B₁₂. Bull. Torrey Bot. Club,
78: 363-375.

SCHREAD, J. C.

1952. Habits and control of the Oriental earthworm. Bull. Conn. Agr.
Exp. Sta., **556**: 1-15.

STEPHENSON, J.

1923. Oligochaeta. In: Fauna of British India including Ceylon and
Burma. London.
1930. The Oligochaeta. Oxford.